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Yu et al.

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(54) **INSTRUMENT FOR CASSETTE FOR SAMPLE PREPARATION**

(71) Applicant: **LUMINEX CORPORATION**, Austin, TX (US)

(72) Inventors: **Steve Jia Chang Yu**, San Jose, CA (US); **Jesus Ching**, San Jose, CA (US); **Phillip You Fai Lee**, San Francisco, CA (US); **David Hsiang Hu**, Palo Alto, CA (US)

(73) Assignee: **LUMINEX CORPORATION**, Austin, TX (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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Related U.S. Application Data

(63) Continuation of application No. 13/459,469, filed on Apr. 30, 2012, now Pat. No. 8,900,877, which is a continuation of application No. 13/234,770, filed on Sep. 16, 2011, now Pat. No. 8,168,443, which is a

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G01N 35/02 (2006.01)

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(52) **U.S. Cl.**
CPC ***C12Q 1/6806*** (2013.01); ***G01N 35/08*** (2013.01); *B01L 3/502707* (2013.01); *B01L 2300/0609* (2013.01); *G01N 35/026* (2013.01); *G01N 35/04* (2013.01); *G01N 2035/00366* (2013.01); *G01N 2035/00544* (2013.01);

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(58) **Field of Classification Search**
CPC C12Q 1/6806; G01N 2035/00366; G01N 2035/00544; G01N 2035/00574; G01N 35/08; G01N 35/04; G01N 35/026; Y10S 436/807; Y10T 436/10; Y10T 436/11; Y10T 436/115831; Y10T 436/25
See application file for complete search history.

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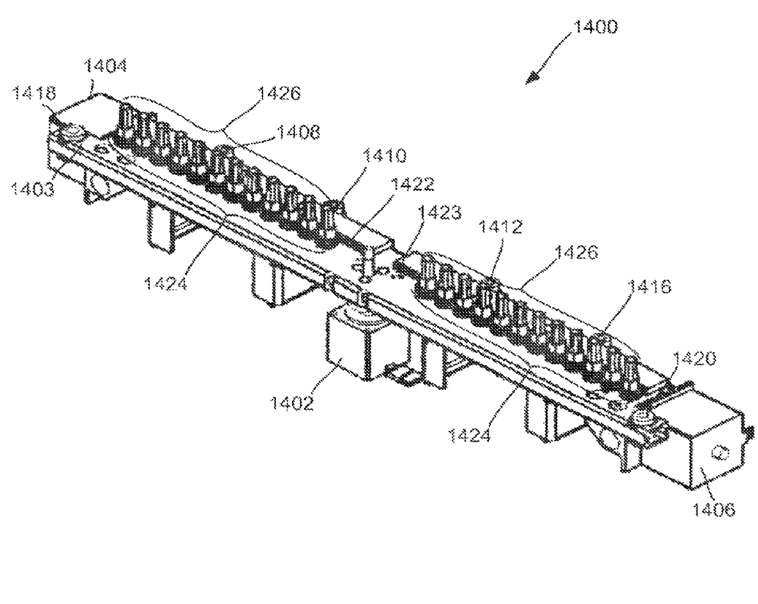
Primary Examiner — Lyle Alexander
Assistant Examiner — Jennifer Wecker
(74) *Attorney, Agent, or Firm* — Parker Highlander PLLC

(57) **ABSTRACT**

A parallel processing system for processing samples is described. In one embodiment, the parallel processing system includes an instrument interface parallel controller to control a tray motor driving system, a close-loop heater control and detection system, a magnetic particle transfer system, a reagent release system, a reagent pre-mix pumping system and a wash buffer pumping system.

15 Claims, 14 Drawing Sheets



Related U.S. Application Data

continuation of application No. 13/044,109, filed on Mar. 9, 2011, now Pat. No. 8,029,746, which is a continuation of application No. 12/821,446, filed on Jun. 23, 2010, now Pat. No. 7,910,062, which is a continuation of application No. 12/005,860, filed on Dec. 27, 2007, now Pat. No. 7,754,148.

(60) Provisional application No. 60/882,150, filed on Dec. 27, 2006.

(51) **Int. Cl.**
G01N 35/04 (2006.01)
G01N 35/08 (2006.01)
C12Q 1/68 (2006.01)
B01L 3/00 (2006.01)

(52) **U.S. Cl.**
CPC *G01N 2035/00574* (2013.01); *G01N 2035/00801* (2013.01); *G01N 2035/0412* (2013.01); *G01N 2035/0415* (2013.01); *Y10S 436/807* (2013.01); *Y10T 436/10* (2015.01); *Y10T 436/11* (2015.01); *Y10T 436/113332* (2015.01); *Y10T 436/115831* (2015.01); *Y10T 436/25* (2015.01)

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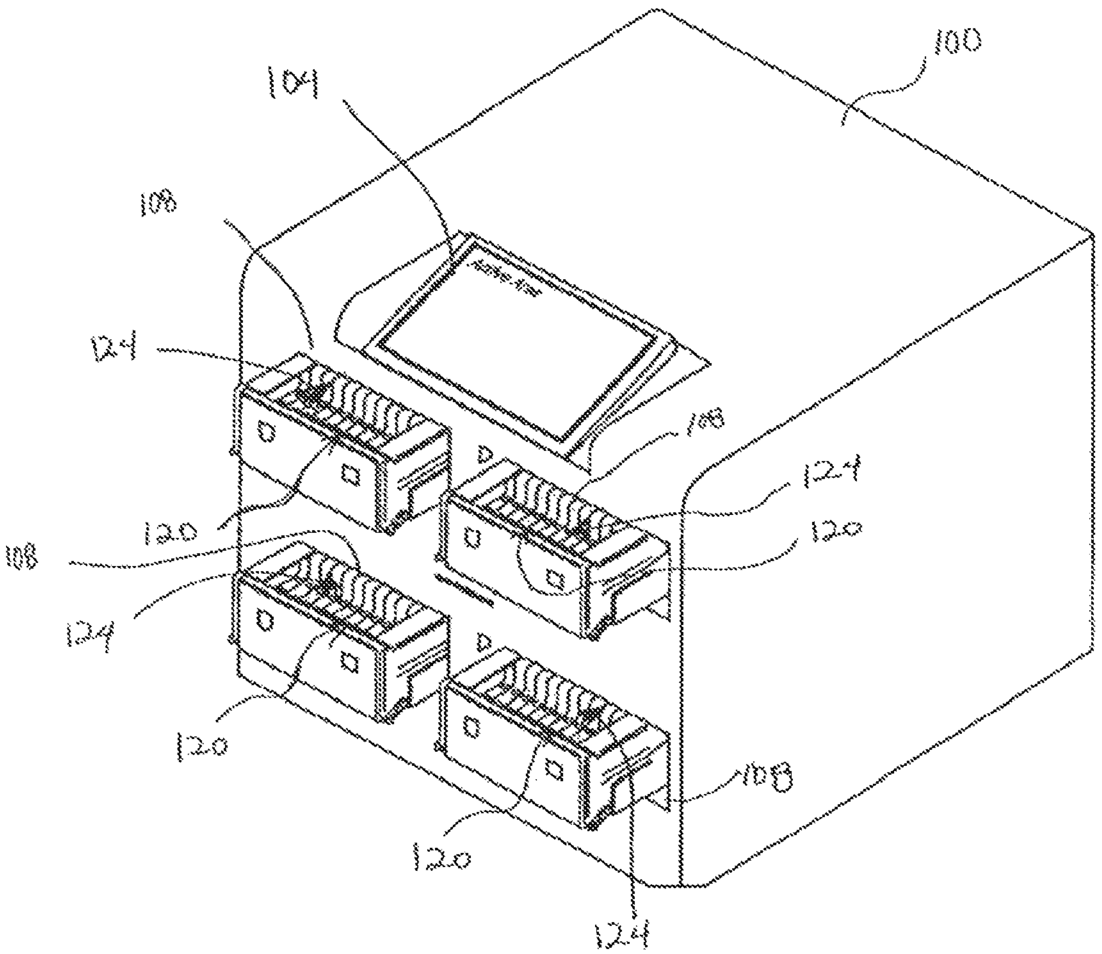


FIG. 1

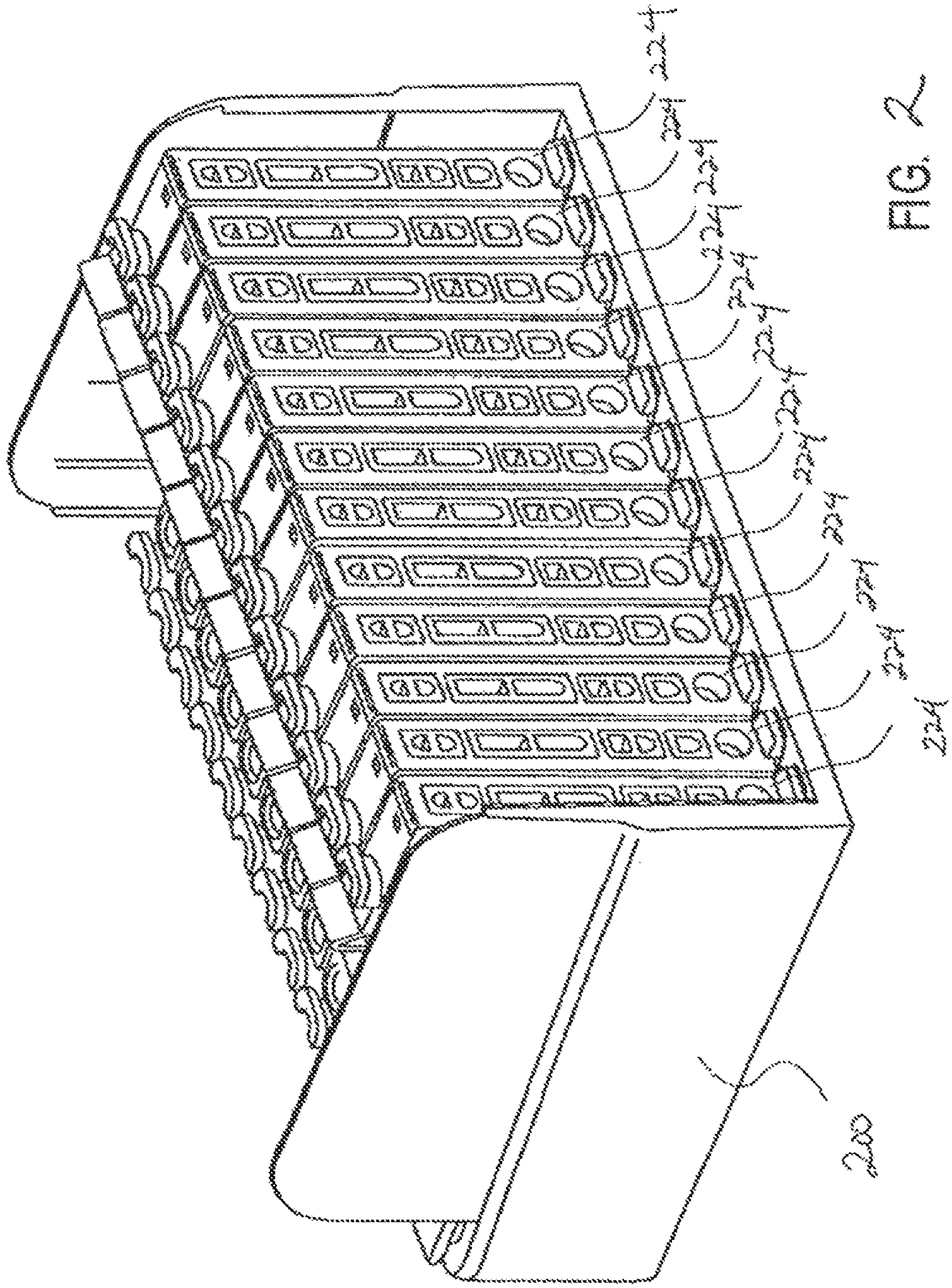
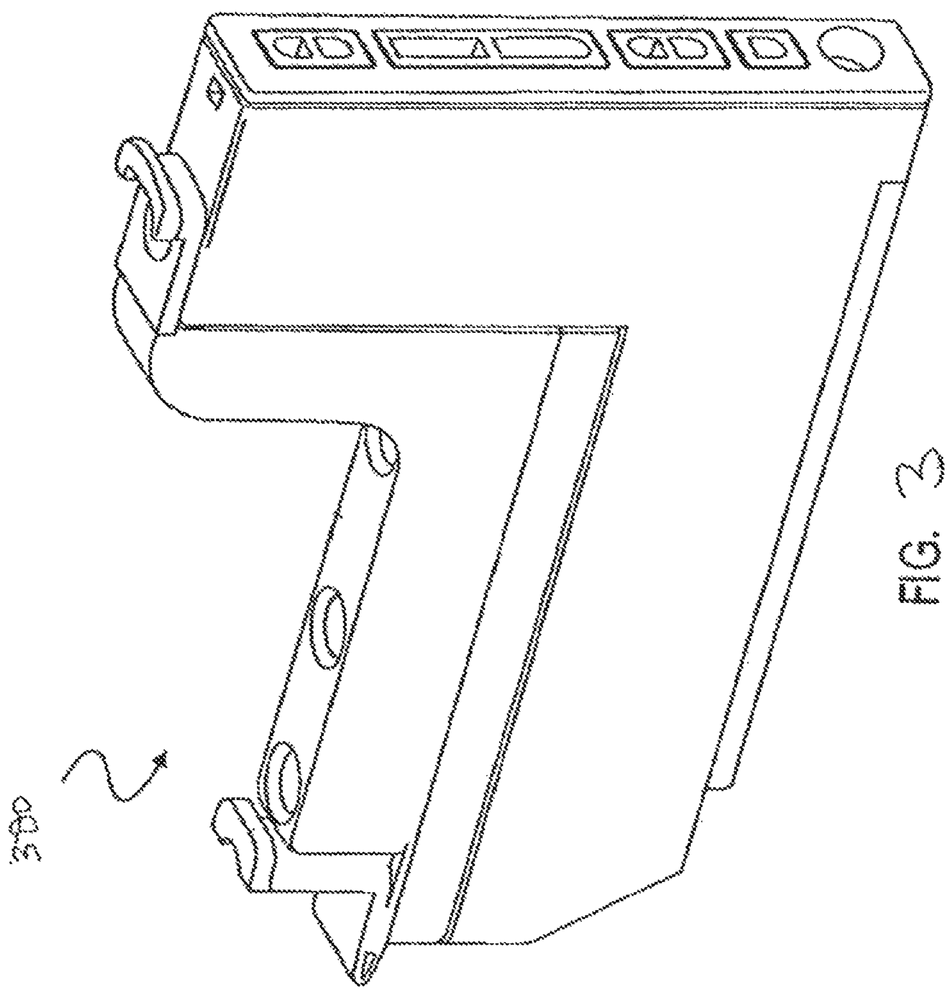


FIG. 2



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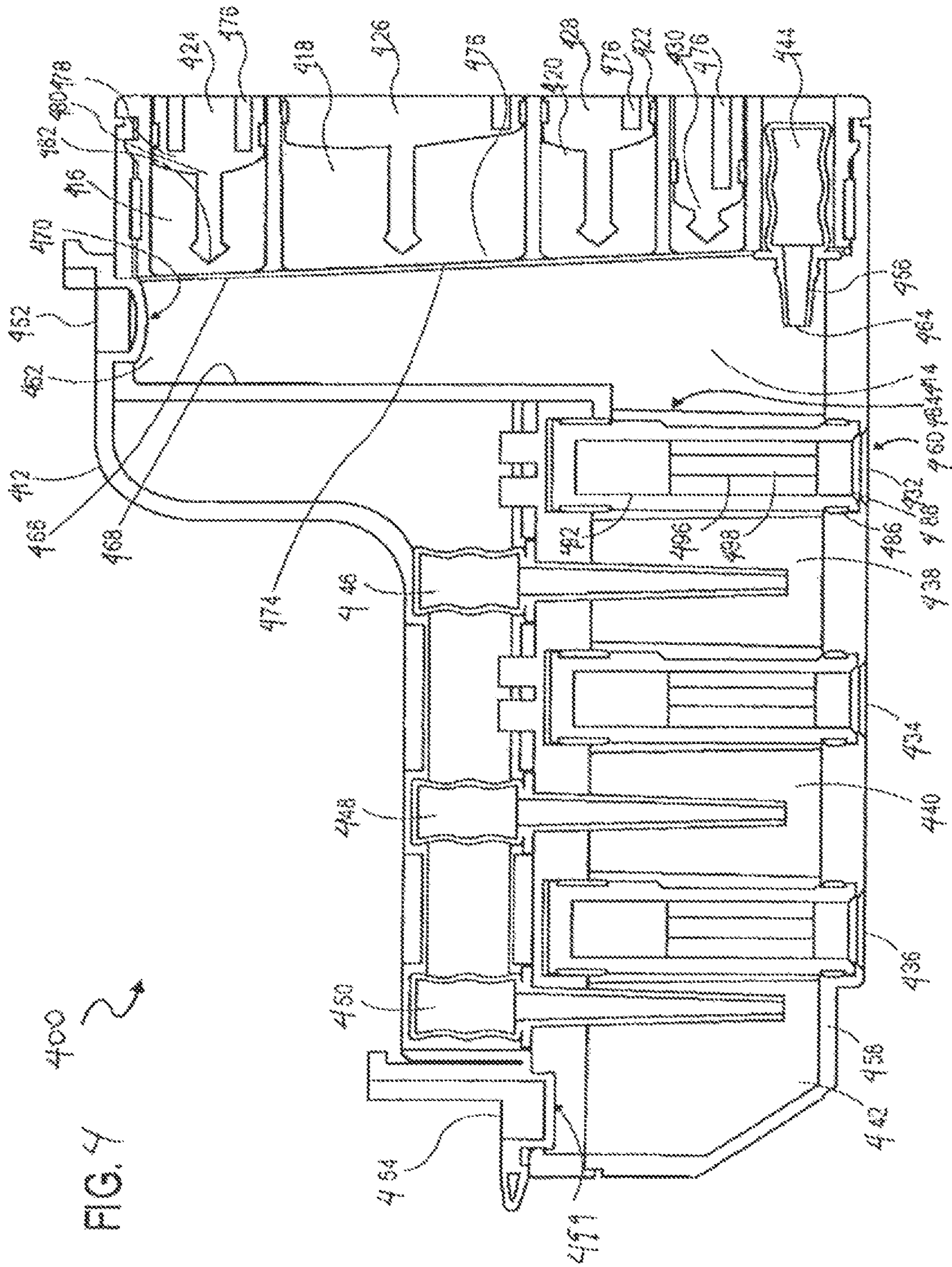
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FIG. 4

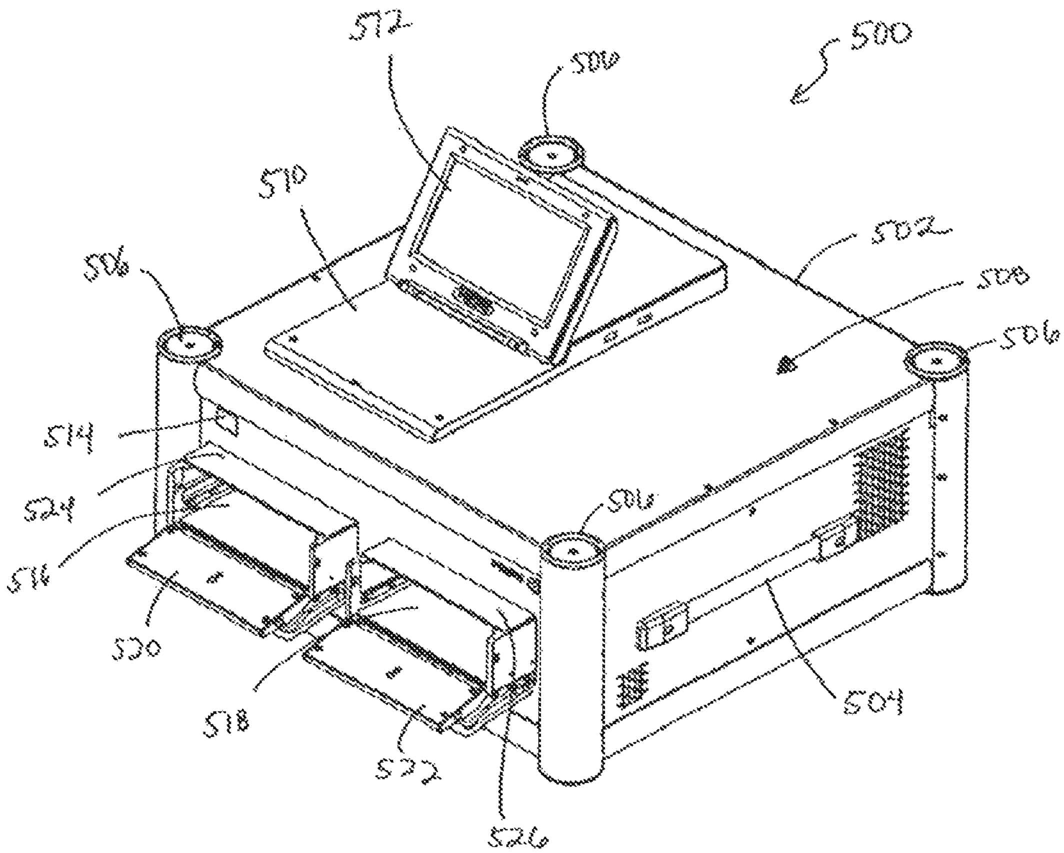
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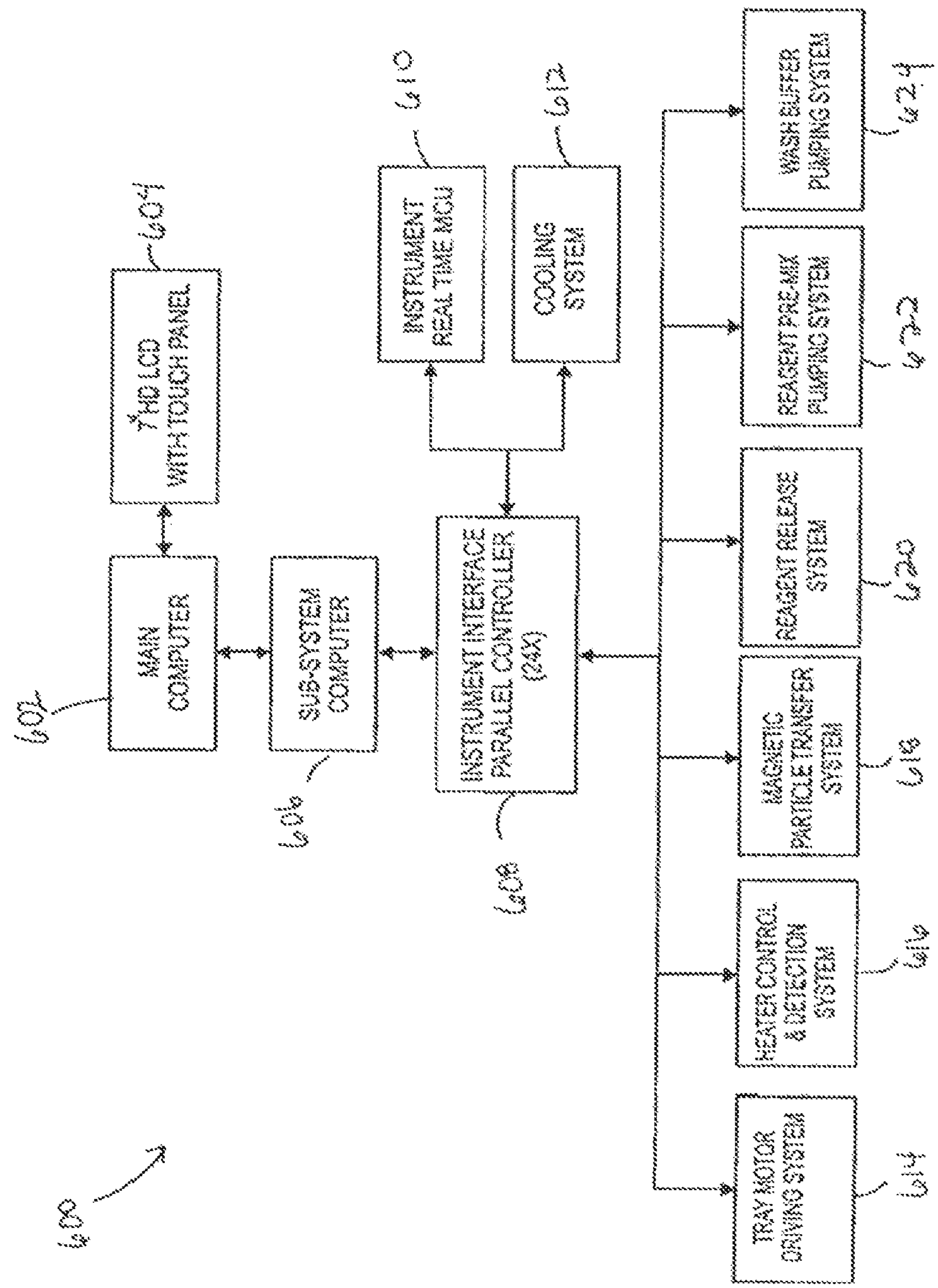
FIG. 5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INSTRUMENT INTERFACE PARALLEL CONTROLLER (24X)
610
INSTRUMENT REAL TIME MCU
612
COOLING SYSTEM
614
TRAY MOTOR DRIVING SYSTEM
616
HEATER CONTROL & DETECTION SYSTEM
618
MAGNETIC PARTICLE TRANSFER SYSTEM
620
REAGENT RELEASE SYSTEM
622
REAGENT PRE-MIX PUMPING SYSTEM
624
WASH BUFFER PUMPING SYSTEM

FIG. 6A

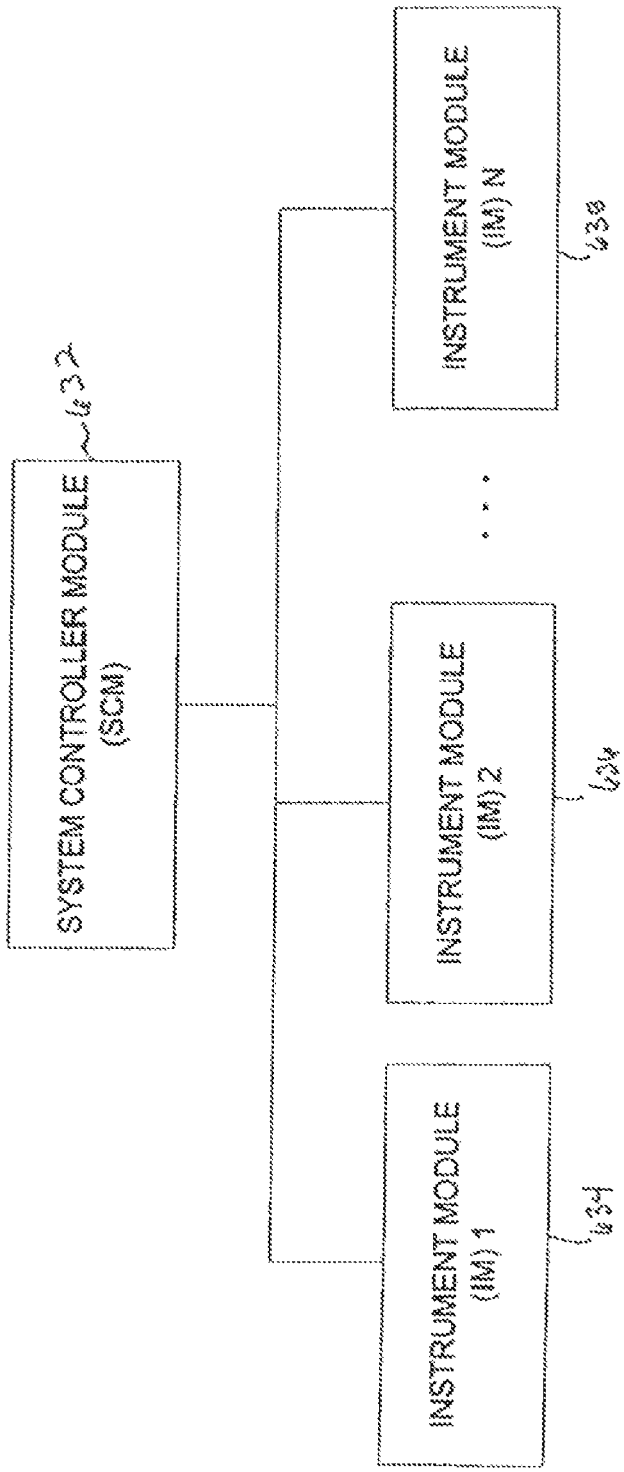
SYSTEM CONTROLLER MODULE (SCM)
632
INSTRUMENT MODULE (IM) 1
INSTRUMENT MODULE (IM) 2
INSTRUMENT MODULE (IM) N
638

FIG. 6B

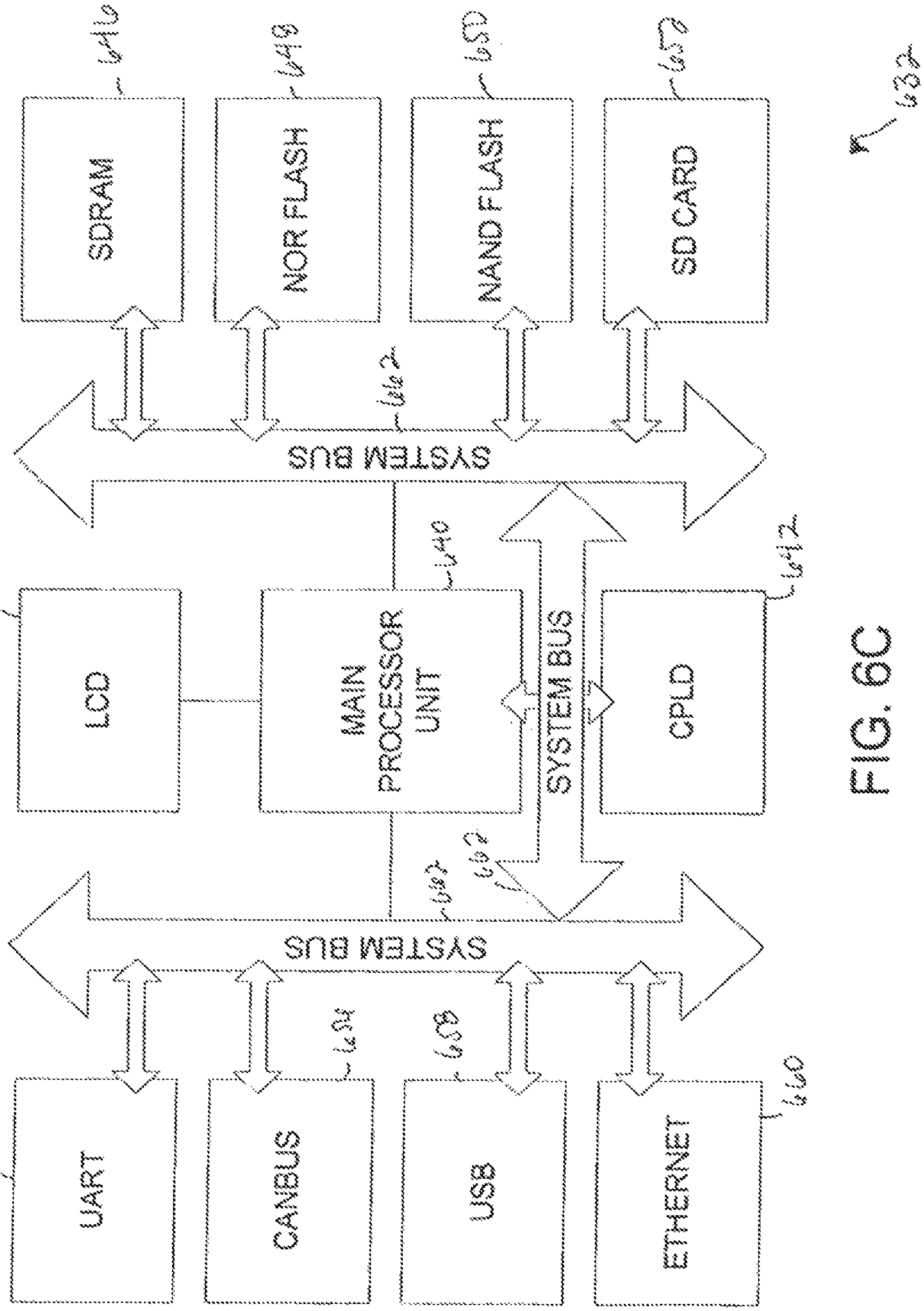
SDRAM
NOR FLASH
NAND FLASH
SD CARD
SYSTEM BUS
LCD
MAIN PROCESSOR UNIT
SYSTEM BUS
CPLD
SYSTEM BUS
UART
CANBUS
USB
ETHERNET

FIG. 6C

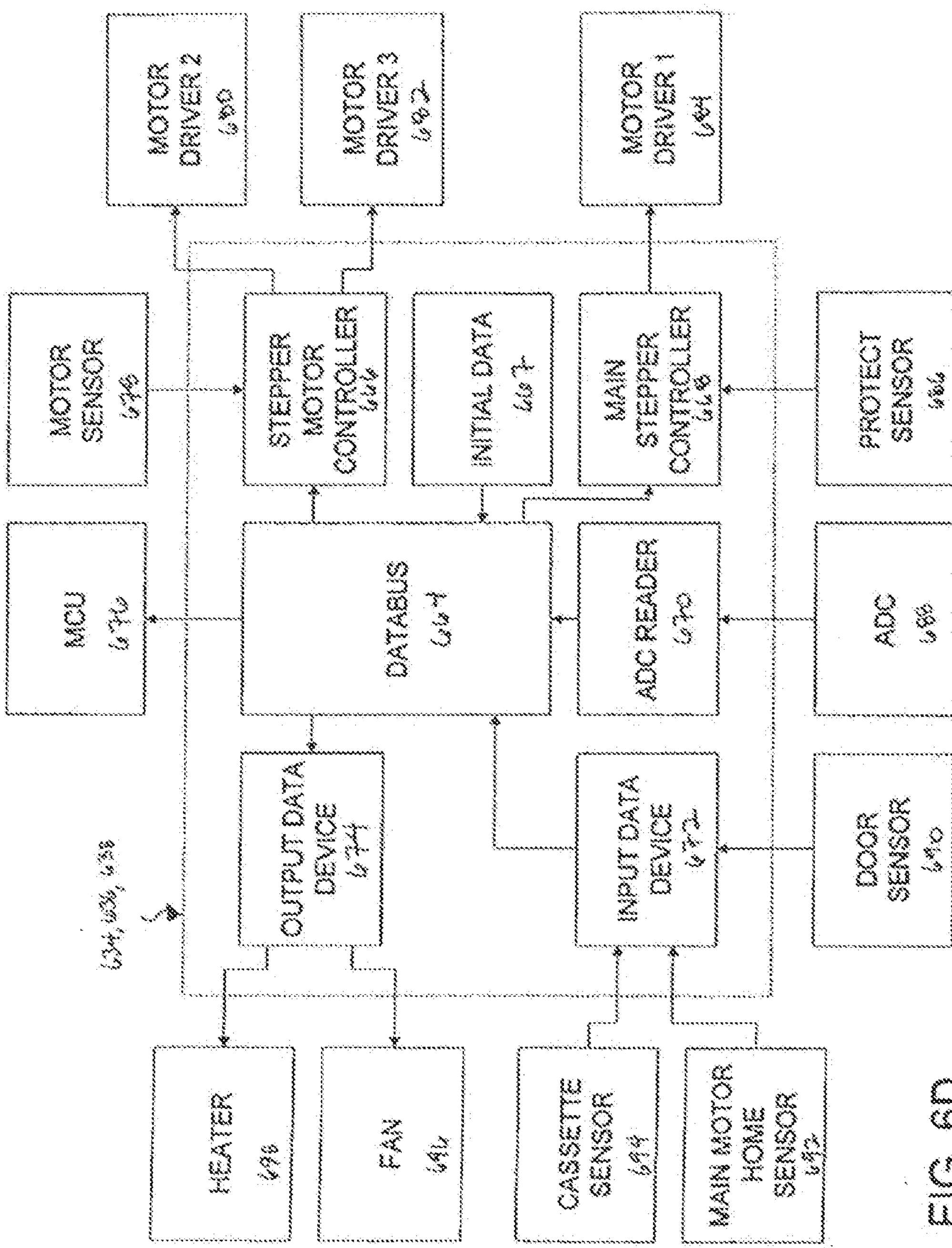
MOTOR DRIVER 2
MOTOR DRIVER 3
MOTOR DRIVER 1
MOTOR SENSOR
STEPPER MOTOR CONTROLLER
INITIAL DATA
MAIN STEPPER CONTROLLER
PROTECT SENSOR
MCU
DATABUS
ADC READER
ADC
OUTPUT DATA DEVICE
INPUT DATA DEVICE
DOOR SENSOR
HEATER
FAN
CASSETTE SENSOR
MAIN MOTOR HOME SENSOR

FIG. 6D

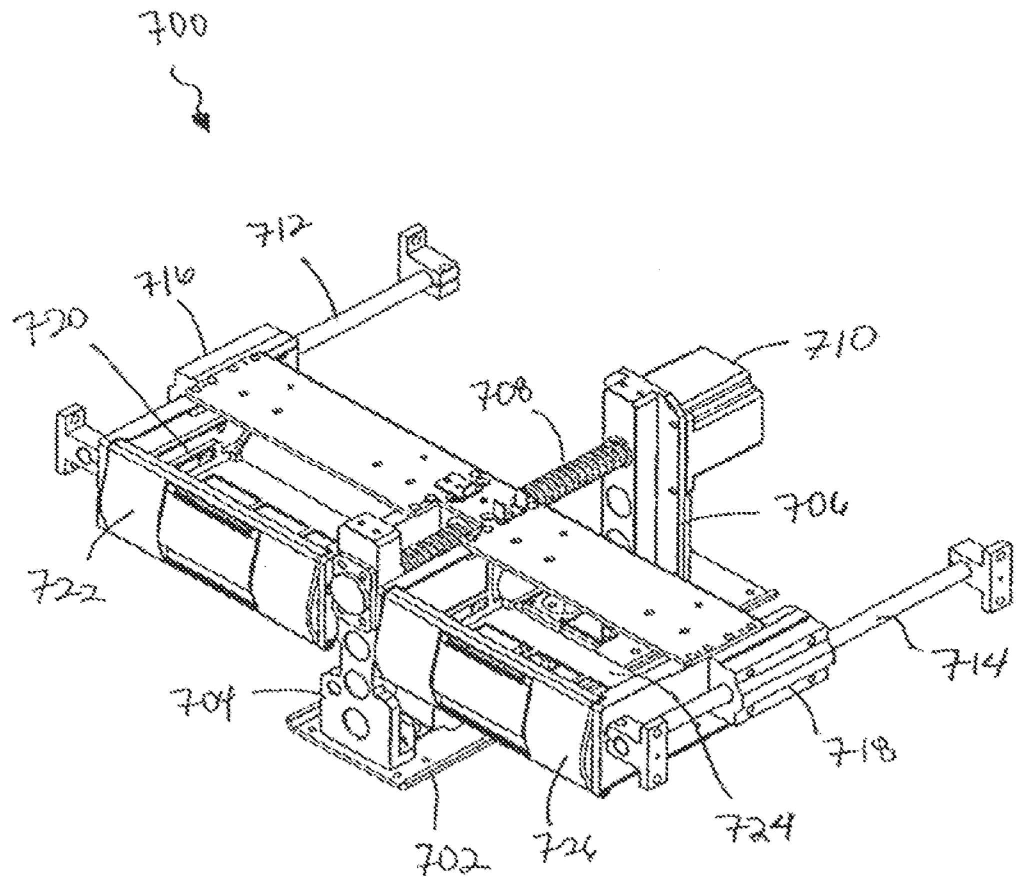

FIG. 7

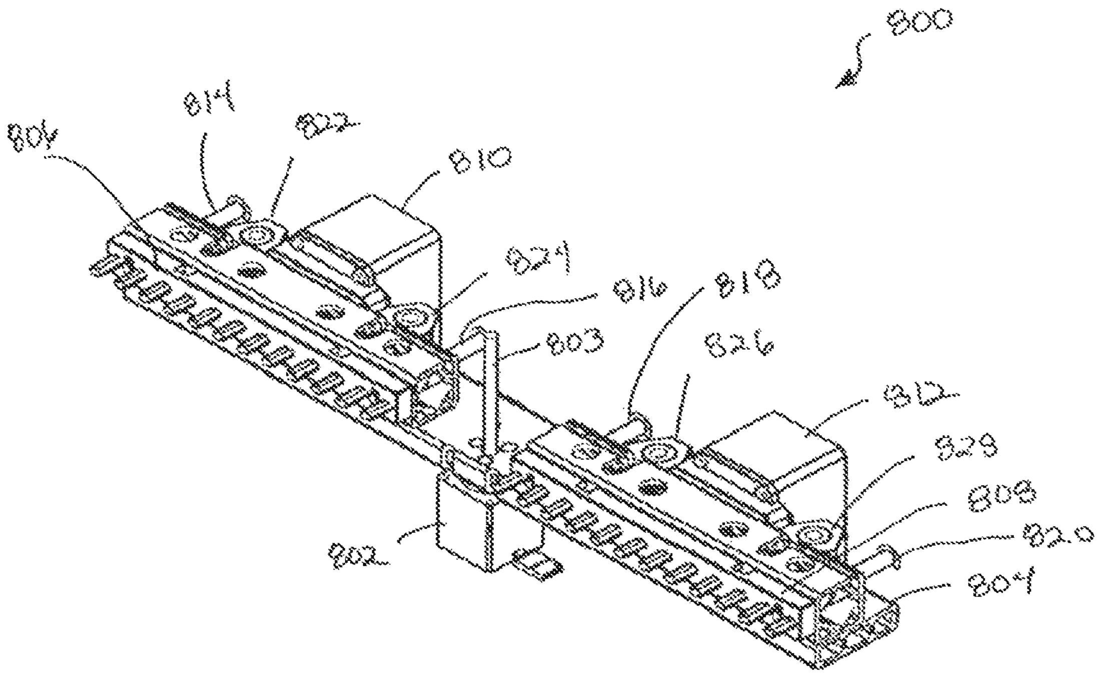
800
806
814
822
810
824
816
818
803
826
812
828
808
820
804
802

FIG. 8

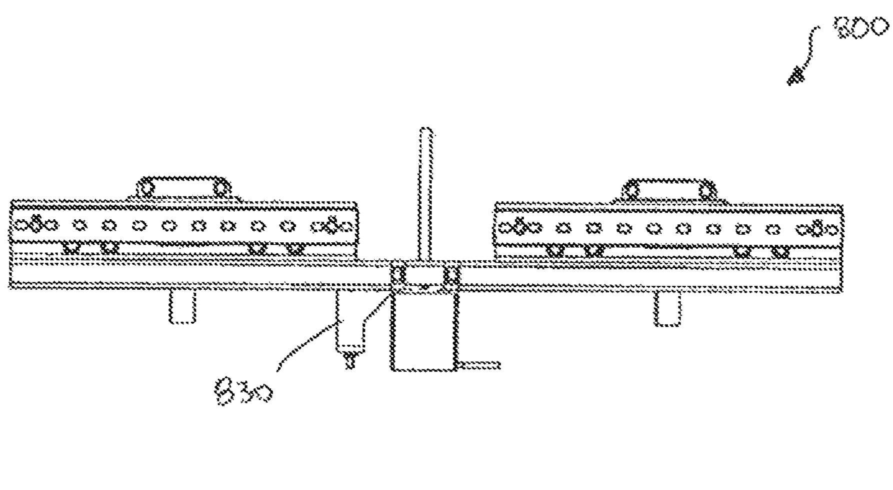
800
830

FIG. 9

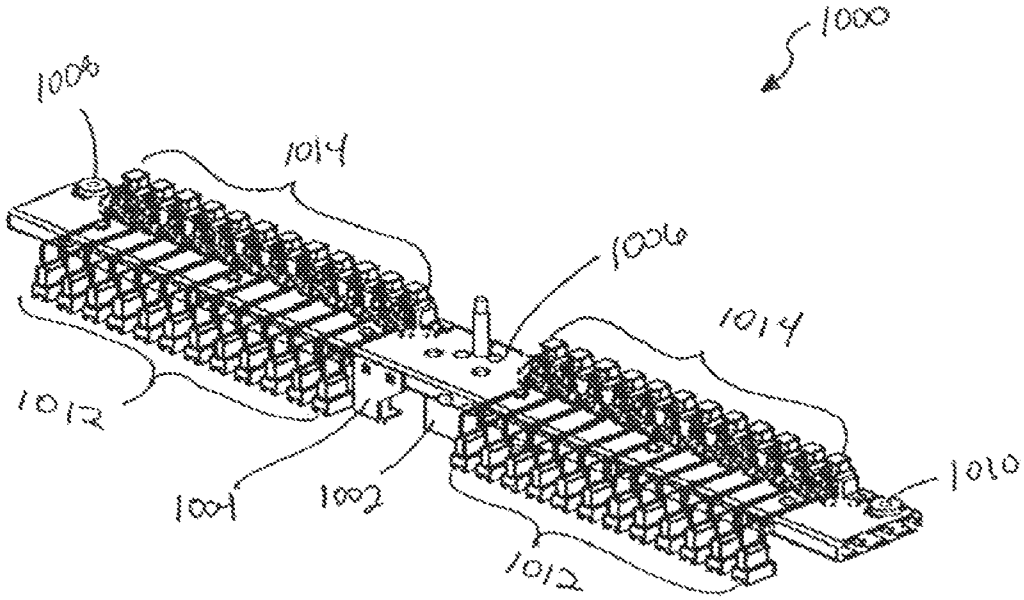

FIG. 10

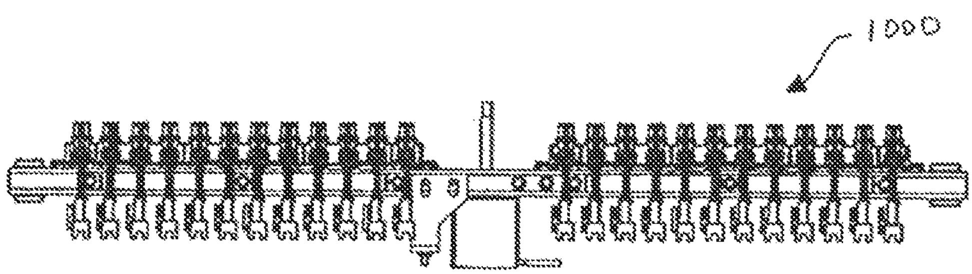

FIG. 11

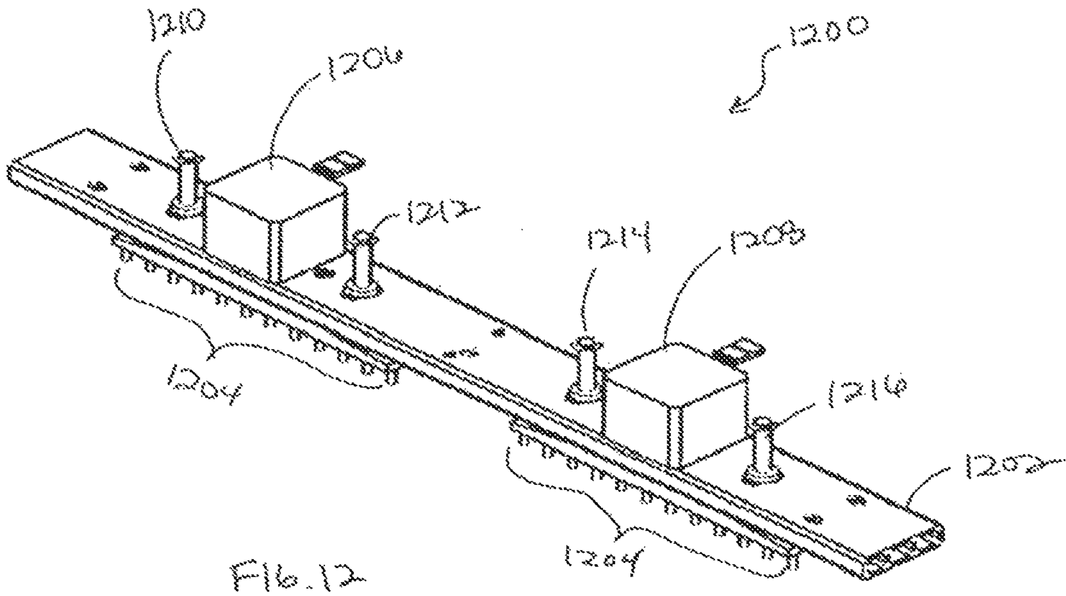
1210
1206
1200
1212
1214
1208
1204
1216
1202
1204

FIG. 12

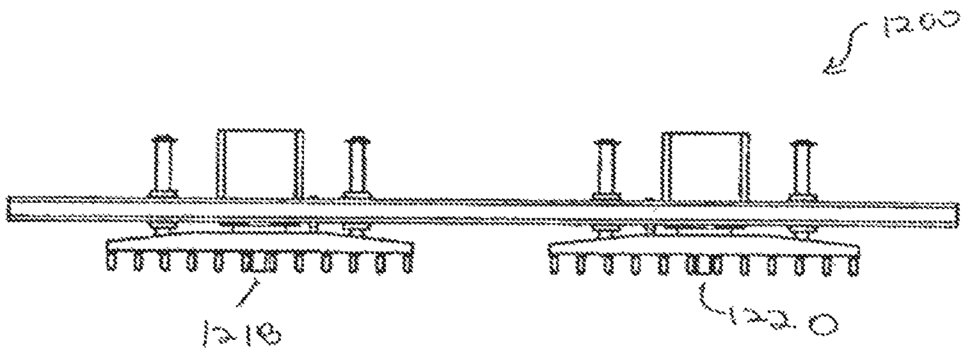
1200
1218
1220

FIG. 13

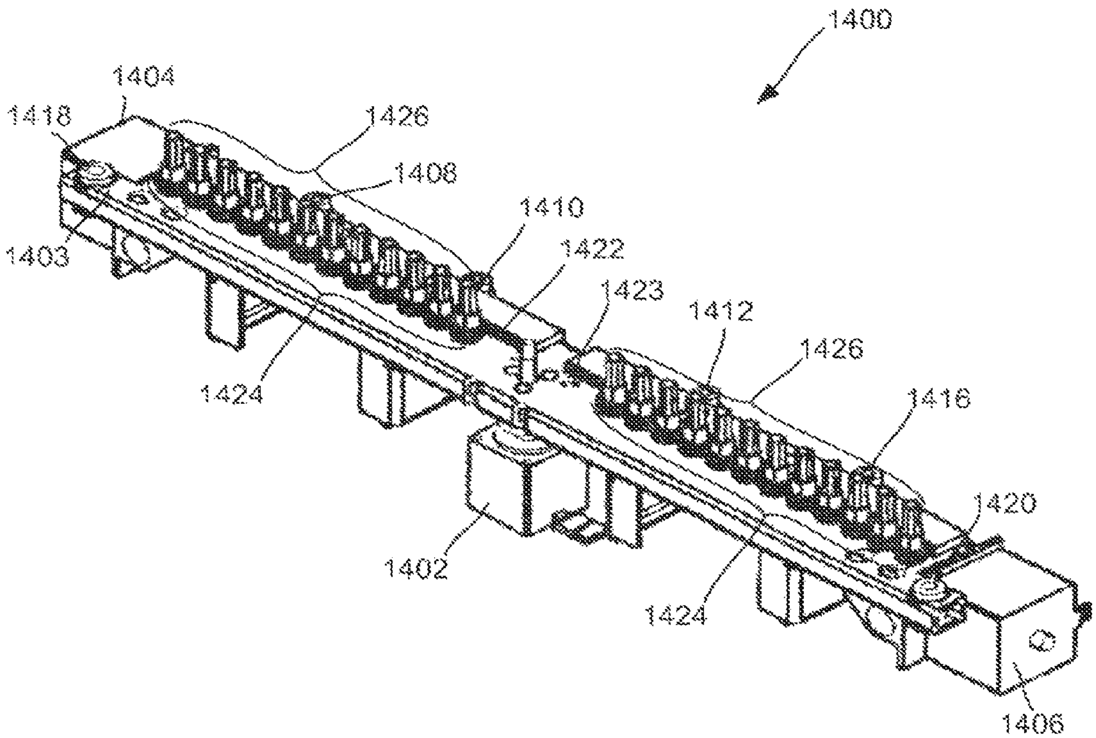
1400
1404
1418
1426
1408
1410
1422
1403
1423
1412
1426
1424
1416
1420
1402
1424
1406

FIG. 14

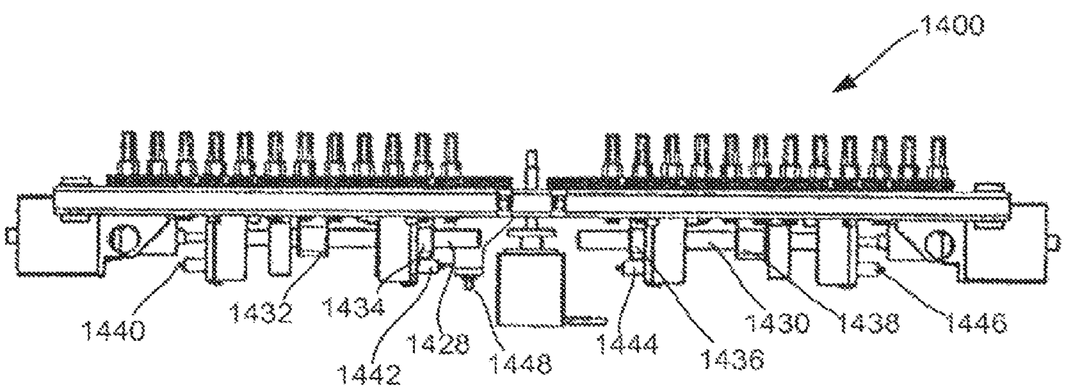
1400
1440
1432
1434
1442
1428
1448
1444
1436
1430
1438
1446

FIG. 15

INSTRUMENT FOR CASSETTE FOR SAMPLE PREPARATION

CROSS-REFERENCES TO RELATED APPLICATIONS

This application is continuation of U.S. patent application Ser. No. 13/459,469 (U.S. Pat. No. 8,900,877), entitled "Instrument for Cassette for Sample Preparation," filed Apr. 30, 2012, which is a continuation of U.S. patent application Ser. No. 13/234,7701 nm U.S. Pat. No. 8,168,443), entitled "Instrument for Cassette for Sample Preparation," filed Sep. 16, 2011, which is a continuation of U.S. patent application Ser. No. 13/044,109 (now U.S. Pat. No. 8,029,746), entitled "Instrument for Cassette for Sample Preparation," filed Mar. 9, 2011, which is a continuation of U.S. patent application Ser. No. 12/821,446 (now U.S. Pat. No. 7,910,062), entitled "Instrument for Cassette for Sample Preparation," filed Jun. 23, 2010, which is a continuation of U.S. patent application Ser. No. 12/005,860 (now U.S. Pat. No. 7,754,148), entitled "Instrument for Cassette for Sample Preparation," filed Dec. 27, 2007, which claims priority to U.S. Provisional Application Ser. No. 60/882,150, entitled "Instrument for Cassette for Sample Preparation," filed Dec. 27, 2006, each of which is incorporated herein by reference in its entirety.

FIELD

The present invention relates to the field of biotechnology devices and, in particular, to devices and methods for preparing samples.

BACKGROUND

DNA can be used to develop new drugs or to link someone to a crime. However, before this can be done, the DNA must be isolated from a sample. These samples include, for example, blood, urine, human cells, hair, bacteria, yeast and tissue. Each of these samples include cells, which include nucleic acid. Nucleic acid is a nucleotide chain, which conveys genetic information. The most common forms of nucleic acid are DNA and RNA.

In order to isolate the nucleic acid from the samples, prior art devices use a tray having several exposed cavities. The sample is placed into one of the cavities and conventional processing steps are used to isolate the DNA from the sample.

This prior art system has several disadvantages, including contamination, and inability to perform parallel processing or asynchronous processing. Since the cavities are exposed, contaminants can easily affect the DNA. In addition, the prior art system requires the preparation of several sampler at one time. In addition, these prior art systems require a significant amount of time to process multiple samples.

SUMMARY

In one embodiment, the present invention relates to on instrument for preparing samples. The instrument includes, for example, a parallel tray motor driving system; a close-loop heater control and detection system; a parallel magnetic particle transfer system; a parallel reagent release system; a reagent parallel pre-mix pumping system; a parallel wash buffer pumping system; and an instrument interlace controller to control the biological sample processing instrument that includes the parallel tray motor driving system, the close-loop heater control and detection system, the parallel magnetic particle transfer system, the parallel reagent release system, the parallel reagent pre-mix pumping system, and the parallel wash buffer pumping system.

In another embodiment, the present invention relates to a system for preparing samples. The system includes, for example, an enclosure; a parallel tray motor driving system in the enclosure to insert one or more magazines which contain one or more cassettes into the enclosure, the cassette having a sample therein; a close-loop heater control and detection system in the enclosure; a parallel magnetic particle transfer system in the enclosure; a parallel reagent release system in the enclosure; a parallel reagent pre-mix pumping system in the enclosure; and a parallel wash buffer pumping system in the enclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is described by way of example with reference to the accompanying drawings, wherein:

FIG. **1** is a perspective view of an instrument for a cassette for sample preparation in accordance with one embodiment of the invention;

FIG. **2** is a perspective view of a magazine insertable into the instrument of FIG. **1** in accordance with one embodiment of the invention;

FIG. **3** is a perspective view of a cassette for preparing samples in accordance with one embodiment of the invention;

FIG. **4** is a cross-sectional side view of the cassette first preparing samples of FIG. **3** in accordance with one embodiment of the invention;

FIG. **5** is a perspective view of an instrument for a cassette for sample preparation in accordance with one embodiment of the invention;

FIG. **6**A is a block diagram of the system of the instrument of FIG. **5** in accordance with one embodiment of the invention;

FIG. **6**B is a top level digital block diagram of the system controller of the instrument of FIG. **5** in accordance with one embodiment of the invention;

FIG. **6**C is a digital processing block diagram of the system controller of the instrument of FIG. **5** in accordance with one embodiment of the invention;

FIG. **6**D is an Instrument Module (IM) block diagram of FIG. **5** in accordance with one embodiment of the invention;

FIG. **7** is a detailed perspective view of a parallel tray driving motor assembly module in accordance with one embodiment of the invention;

FIG. **8** is a detailed perspective view of the reagent release and pre-mix assembly module in accordance with one embodiment of the invention;

FIG. **9** is a detailed side view of the reagent release and pre-mix assembly module in accordance with one embodiment of the invention;

FIG. **10** is a detailed perspective view of a close-loop heater and temperature sensor assembly module in accordance with one embodiment of the invention;

FIG. **11** is a detailed side view of the close-loop heater and temperature sensor assembly module in accordance with one embodiment of the invention;

FIG. **12** is a detailed perspective view of a parallel wash buffer pumping assembly module in accordance with one embodiment of the invention;

FIG. **13** is a detailed side view of the parallel wash buffer pumping assembly module in accordance with one embodiment of the invention;

FIG. **14** is a detailed perspective view of a parallel magnetic particles transfer assembly module its accordance with one embodiment of the invention; and

FIG. **15** is a detailed side view of the parallel magnetic particles transfer assembly module in accordance with one embodiment of the invention.

DETAILED DESCRIPTION

FIG. **1** illustrates an instrument **100** in accordance with one embodiment of the invention. In one embodiment, the instrument **100** is a parallel processing system.

The illustrated instrument **100** includes a display **104** and openings **108**. The openings **108** are configured to receive magazines **120**. The magazines **120** each contain a series of cassettes **124**. Each cassette includes a sample of cells to be prepared. A protocol may be selected by a user at the display **104** for preparing the sample in the cassette **124** within the instrument **100**. The instrument **100** then automatically prepares the sample within the instrument according to the selected protocol.

In the embodiment illustrated in FIG. **1**, the instrument can process four magazines **120**, each magazine **120** having twelve cassettes **124**, each cassette having a sample of cells therein at the same time according to the selected protocol. It will be appreciated, however, that fewer than forty-eight or greater than forty-eight samples can be processed at a time.

FIG. **2** illustrates a magazine **200** in further detail. In one embodiment, the magazine **200** is the magazine **120** of FIG. **1**. In one embodiment, the magazine **200** is a rack. Several cassettes **224** (e.g., cassettes **124** from FIG. **1**) are placed into the magazine **200**.

FIG. **3** illustrates a cassette **300** in further detail. In one embodiment, the cassette **300** is the cassettes **124** in FIG. **1** and/or cassettes **224** in FIG. **2**. The cassette **300** can be used to prepare cell samples.

FIG. **4** is a detailed view of the cassette of FIG. **3**. The cassette **400** includes a housing **412**, a mixing chamber **414**, first, second, third and fourth holding chambers **416**, **418**, **420** and **422**, first, second, third and fourth plungers **424**, **426**, **428** and **430**, first, second, and third valves **432**, **434** and **436**, first and second washing chambers **438** and **440**, an elution chamber **442**, first, second, third and fourth pumps **444**, **446**, **448** and **450**, first and second lids **452** and **454**, first and second heating elements **456** and **458** and a magnetic **460**. Each of the chambers **414**, **416**, **418**, **420**, **422**, **438**, **440** and **442**, plungers **424**, **426**, **428** and **430**, valves **432**, **434**, **436**, pumps **444**, **446**, **448** and **450**, and heating elements **456** and **458** are enclosed within the housing **412**. The lids **452** and **454** are movably attached to the housing **412**. The magnet **460** is removably positionable in the first valve **432**, second valve **434** and third valve **436**.

The mixing chamber **414** has a top surface **462**, a bottom surface **464** and opposing side surfaces **466**, **468**. The top surface **462** of the mixing chamber **414** includes an opening **470** therein.

The first lid **452** is configured to provide access to the opening **470** in the top surface **460** of the mixing chamber **414**. The first lid **452** and the opening **470** are coaxial. The first lid **452** is shown being movably attached to the housing **412**, such that when the lid **452** is open or off, the opening **470** is accessible and if the lid **452** is closed or on, the opening **470** is not accessible.

A thin film **474** forms one wall of the mixing chamber **414**. The thin chamber **474** is breakable, such that the mixing chamber **414** is accessible when the thin film **474** has been broken or ruptured.

The first holding chamber **416**, second holding chamber **418**, third holding chamber **420** and fourth holding chamber **422** are shown located next to the mixing chamber **414** and aligned vertically with one another. Each of the holding chambers **416**, **418**, **420**, **422** has an opening **476** next to the thin film **474** of the mixing chamber **414**.

The cassette **400** further includes magnetic iron particles in the form of magnetic beads in the first holding chamber **416**. The cassette **400** further includes a binding solution in the second holding chamber **418**. The cassette **400** further includes a lysis solution in the third holding chamber **420**. The cassette **400** further includes a proteinase K (PK) solution in the fourth holding chamber **422**. The magnetic iron particles (in the form of magnetic beads), lysis solution, binding solution, and proteinase K (PK) can also be provided in any chamber of the cassette **400** based on desired protocol.

The first, second, third and fourth plungers **424**, **426**, **428** and **430** are located in the first, second, third and fourth holding chambers **416**, **418**, **420** and **422**, respectively.

Each of the plungers **416**, **418**, **420**, **422** includes a base **478**, a shaft **480** and a piercing element **482**. The shaft **480** extends from the base **478**. The piercing element **482** is at the end of the shall **480** opposing the base **478** and is pointed. The piercing element **482** is configured to break or rupture the thin film **474** of the mixing chamber **414**.

The first pump **444** is a bellows pump having a pumping portion and a nozzle portion. The nozzle portion of the first pump **444** is located inside the mixing chamber **414**. The pumping portion of the first pump **444** is located outside the mixing chamber, such that the pumping portion is actuatable.

A heating element **456** is provided at the bottom surface **464** of the mixing chamber **414** for heating the contents of the mixing chamber **414**. The heating element **456** may be a variable heating element.

The opposing side surface **468** of the mixing chamber **414** also includes an opening **484**. A first valve **432** is provided between the opening **484** in the side **468** of the mixing, chamber **414** and the first washing chamber **438**.

The first valve **432** has a first stationary piece **486** and a second moveable piece **488**, the second piece **488** being moveable relative to the first piece **486**. The first stationary piece **486** includes a first opening **490** and a second opening **492** and has a surface **494**. The second piece **488** has an opening **495** therein for receiving the magnet **460**. The second piece **488** has a surface **496** with a cavity **498** therein. The magnet **460** is shaped to correspond to the opening **495** in the second piece **488**. The magnet **460** is moveable in the opening **495** of the second piece **488**, and is removable from the second piece **488**.

The cassette **400** includes a washing solution in the first washing chamber **438**. The second pump **446** is also a bellows pump, and the nozzle portion of the second pump **446** is located in the first washing chamber **438**.

The second vale **434** is provided between the first washing chamber **438** and the second washing chamber **440**. The second vale **434** is structurally and functionally the same as the first vale **432**, and also includes a first stationary piece **486** and a second moveable piece **488**. The first stationary piece **486** includes a first opening **490** and a second opening **492** and has a surface **494**. The second moveable piece has a surface **496** with a cavity **498** therein.

The cassette **400** includes a washing solution in the second washing chamber **440**. The third pump **448** is also a bellows pump, and the nozzle portion of the third pump **448** is located in the second washing chamber **440**.

The third valve **436** is provided between the second washing chamber **440** and the elution chamber **442**. The third valve

436 is structurally and functionally the same as the first valve 432, and also includes a first stationary piece 486 and a second moveable piece 488. The first stationary piece 486 includes a first opening 490 and a second opening 492 and has a surface 494. The second moveable piece has a surface 496 with a cavity 498 therein.

The cassette 400 includes a washing solution in the elution chamber 442. The fourth pump 450 is also a bellows pump, and the nozzle portion of the fourth pump 450 is located in the elution chamber 442.

A heating element 458 is provided at the bottom surface of the elusion chamber 442 for heating the contents of the elution chamber 442. The heating element 458 may be a variable heating element.

The elution chamber 442 includes an opening 499 at its top surface for accessing the contents of the elution chamber 442.

The second lid 442 is configured to provide access to the opening 499 in the top surface of the elution chamber 442. The second lid 454 is coaxial with the opening 499. The second lid 454 is shown being movably attached to the housing 412, such that when the lid 454 is open or off, the opening 499 is accessible and if the lid 454 is closed or on, the opening 499 is not accessible.

In use, the first lid 452 is removed to provide access to the opening 470 of the mixing chamber 414. A sample of cells is placed into the cassette 400 and, in particular, into the mixing chamber 414. The cells in the sample include nucleic acid.

The PK solution is then added to the sample. The PK solution is added by moving the plunger 430 in the fourth holding chamber 422. A force is applied to the base 478 of the plunger 430 to move the plunger 430. As the piercing element 482 of the plunger 430 advances toward the mixing chamber 414, the piercing element 482 punctures and ruptures the thin film 474. The break in the thin film 474 provides access to the mixing chamber 414. Continued motion of the plunger 430 transfers the contents (e.g., PK solution) of the first holding chamber 422 into the mixing chamber 414.

The PK solution is mixed with the sample by pumping the mixture with, for example, the first pomp 444. The PK solution breaks up/destroys the walls of the cells of the sample, creating bulk material and nucleic acid in the bulk material.

The lysis solution is then added to the sample in a manner similar to the PK solution. The lysis solution is typically a salt or detergent. The lysis solution is used to solulibize the bulk material. The lysis solution typically does not solulibize proteins.

The heating element 456 may be used to heat the lysis solution and sample. As described hereinabove, the temperature of the heating element 456 may be variable, and is selected to optimize the effectiveness of the lysis solution.

The binding solution is then added to the sample, PK solution and lysis buffer solution. The binding solution is typically hydrophobic and increases salt in the solution. The binding solution causes the nucleic acid to be magnetically charged.

The magnetic beads are then added to the solution and pumped. The magnetic beads bind to the magnetically charged nucleic acid.

The magnetic beads, together with the nucleic acid, are bound to the first valve 432. The removable positionable magnet 460 is placed in the first valve 432 and slid to a position in the first valve 432 to attract the magnetic beads, which are bound to the nucleic acid, from the mixing chamber 414 to the first valve 432.

The magnetic beads, together with the nucleic acid, are then moved from the mixing chamber 414 and received in the first washing chamber 438.

The magnet 460 is inserted into the opening 494 of the second piece 488. The magnet 460 is inserted to a position corresponding to the openings 490 and 492 of the first piece 486. The magnet 460 attracts the magnetic beads from the mixing chamber 414 through the opening 490 in the first piece 486 and into the cavity 498 in the second piece 488. The second piece 488 is rotated such that the magnetic beads are sealed in the cavity 498 of the second piece 488, between surfaces of the second piece 488 and the first piece 486. The second piece 488 is rotated past the surface 494 of the first piece 486, such that the cavity 498 is accessible in the opening 492 of the first piece 486. The magnet 460 is then removed from the opening 494 in the second piece 488 to release the magnetic beads from the cavity 498 in the second piece 488.

The magnetic beads and nucleic acid are then washed with the washing solution by pumping the solution with the second pump 446. The magnetic beads, together with the nucleic acid, are then bound to the second valve 434 by inserting the magnet 460 into the second valve 434.

The magnetic beads, together with the nucleic acid, are then moved from the first washing chamber 438 to the second washing chamber 440 using the second valve 434. The second valve 434 transfers the magnetic beads and nucleic acid from the first washing chamber 438 to the second washing chamber 440.

The magnetic beads and nucleic acid are then washed with the washing solution a second time by pumping the solution with the third pump 448. The magnetic beads, together with the nucleic acid, are then bound to the third valve 436 by positioning the magnet 460 in the third valve 436.

The magnetic beads and nucleic acid are then moved from the second washing chamber 440 to the elution chamber 442. The magnetic beads and nucleic acid are transferred from the second washing chamber 440 to the elution chamber 442.

An elution buffer solution is then mixed with the magnetic beads and nucleic acid by pumping the solution with the fourth pump 450. The heating element 458 may be used to heat the elution buffer, magnetic beads and nucleic acid. The temperature may be variable and may be selected to optimize release of the nucleic acid from the magnetic beads.

The magnetic beads alone are then bound again to the third valve 436 by positioning the magnet 460 in the third valve 436.

The magnetic beads alone are then moved from the elution chamber 442 back into the second washing chamber 440, leaving the nucleic acid in the elution chamber 442. The magnetic beads are transferred from the elution chamber 442 to the second washing chamber 440.

The prepared sample of nucleic acid may be accessed from the opening 499 in the elution chamber 442. The second lid 54 is removed to provide access to the opening 499 in the elution chamber 42.

In one embodiment, a pipette or a multi-channel pipette may be used to place the sample in the cassette and/or access the sample or a plurality of samples in the cassette(s).

It will be appreciated that the cassette may vary from that illustrated and described above. For example, seals may be provided in the cassette as need. In another example, although the cassette 400 has been described as having a mixing chamber 414, two washing chambers 438 and 440 and an elution chamber 442, it is envisioned that only one washing chamber or no washing chamber may alternatively be provided.

In another example, the valves may have a different arrangement than that described above. In another example, although the cassette has been described as using a single removable magnet 460, it is envisioned that each valve may include a positionable magnet, such that the magnet does not need to be removed. The magnet **460** may be rotatable, and used to rotate the second piece of the valves. Alternatively, the magnet may only slide inside of each of the valves, and the second piece is rotated independent of the magnet. It is envisioned that a cassette **400** that does not use valves as described herein may be used to transfer the magnetic particles from the mixing chamber to the elution chamber. In such an embodiment, a slideable magnet may be provided to transfer the magnetic particles from one chamber to the next.

It is envisioned that the housing **412** may be transparent, such that the procedure can be viewed. In one embodiment the thin film **474** is a lamination. In one embodiment, the lids **452** and **454** may be screw-top lids. In one embodiment, the lids **452**, **454** include a hydrophobic membrane, which allows gasses to vent through the lid, but does not allow the liquids to escape the cassette **400**. In one embodiment, pump **450** is insertable into opening **499**. In one embodiment, pump **450** can also be used as a pipette to remove the sample from the cassette **400**. It is also envisioned that the mixing chamber **414** may be provided without a puncturable thin film **474**. In such an embodiment, the plungers **424**, **426**, **428** and **430** would not need a piercing element **482**. Instead, the plungers **424**, **426**, **428** and **430** would have a sealing element to prevent leakage of the contents of the holding chamber **416**, **418**, **420** and **422**, associated with each plunger **424**, **426**, **428** and **430**, respectively, until the plunger was moved.

In one embodiment, a total of about 200 μL sample is placed into the cassette. The sample is mixed with a total of about 50 μL of the PK solution by pumping the mixture of the sample and PK solution for about one minute. A total of about 200 μL of the lysis solution is added to the sample and PK solution, and the solutions are pumped for about one minute to mix the solutions. The mixture is then heated at about 60° C. for about ten minutes, and the mixture is allowed to cool for about 5 minutes. The mixture is further pumped while it cools. A total of about 500 μL of binding solution is added to the mixture. The solutions are pumped for about one minute. The magnetic beads are added to the solution and pumped for about two minutes. The magnetic beads are transferred and washed as described above. A total of about 700 μL of washing solution is provided in each of the washing chambers. A total of about 200 μL of elution solution is provided in the elution chamber. The magnetic beads are mixed with the elution solution by pumping the mixture for about one minute. The mixture is then heated at about 90° C. for about two minutes. The process continues as previously described. It will be appreciated that the amounts, times and temperatures described above may vary from that described above.

Although the cassette **400** has been described as using a PK solution, lysis solution, binding solution and magnetic beads to release the nucleic acid and magnetic beads, it is envisioned that it may be possible to practice the invention without using each of the above solutions. In addition, although the solution was described as using a PK solution to break up the cells, it is envisioned that any enzyme which causes cells to break up to release nucleic acid may be used with the invention. Furthermore, it will be appreciated that additional solutions may be provided, as needed, to prepare the sample. One of skill in the art will also understand that the cassette **400** may be modified to have fewer holding chambers if fewer solutions are used or additional holding chambers if additional solutions are used.

FIG. **5** illustrates another embodiment of an instrument **500** in accordance with one embodiment of the invention. It will be appreciated that the magazine and cassettes described herein with reference to FIGS. **2-4** can be used with the instrument **500**. The instrument **500** allows for parallel processing of one or more samples within a closed, sterile environment.

Instrument **500** includes an enclosure **502**, an instrument handle **504**, stackable holders **506**, an instrument module **508**, a computer module **510**, a touch panel display **512**, an instrument run time indicator **514**, first and second automatic eject/load trays **516**, **518**, first and second tray doors **520**, **522**, and first and second tray safety guards **524**, **526**.

The instrument module **508** is within the enclosure **502** and is configured to perform the protocol selected to prepare the sample. The protocol is selected by the user using the touch screen display **512**. In one embodiment, the display **512** is a touch screen display. For example, the display **512** may be, for example, a 7" to 12" touch screen LCD display. The user's selection at the display **512** is communicated to the computer module **510** which communicates with the instrument module **508** via a controller area network, bus (CAN-BUS) to coordinate processing within the instrument **500**.

The stackable holders **506** enable multiple instruments **500** to be stacked on top of one another such that even more samples can be processed at any given time. In one embodiment, one computer module **510** and display **512** may be provided to control processing within multiple stacked instruments.

The first and second automatic eject/load trays **516**, **518** are configured to receive a magazine (e.g., magazine **200**) having one or more cassettes therein (e.g., cassette **400**). The magazines are automatically loaded into the instrument **500** by the automatic eject/load trays **516**, **518**. The first and second cassette doors **520**, **522** are closed and engage with the first and second tray safety guards **524**, **526** to secure the magazine and cassettes within the enclosure **502** of the instrument **500** for preparation of the sample. It will be appreciated that in alternative embodiments the trays **516**, **518** and/or doors **520**, **522** may be manually opened and closed.

In one, embodiment, the instrument run time indicator **514** is an LED or other exemplary light source. The instrument run time indicator **514** is illuminated to indicate to a user about the instrument ID and run status. In one embodiment, the computer module **510** provides an indication to the instrument run time indicator **514** to illuminate the communication status between the controller and the instrument.

FIG. **6**A is a block diagram of the system components **600** of the instrument **500**. The system components **600** include, a main computer **602**, a display panel **604**, a sub-system computer **606**, an instrument interface parallel controller **608**, an instrument real time microcontroller unit (MCU) **610**, a cooling system **612**, a tray motor driving system **614**, a heater control and detection system **616**, a magnetic particle transfer system **618**, a reagent release system **620**, a reagent pre-mix pumping system **622** and a wash buffer pumping system **624**.

Each of the cooling system **612**, tray motor driving system **614**, heater control and detection system **616**, magnetic particle transfer system **618**, reagent release system **620**, reagent pre-mix pumping system **622** and wash buffer pumping system **624** communicate with the instrument interface parallel controller **608**. In one embodiment, the instrument interlace parallel controller is configured to control the subsystem **612-624** such that up to twenty-four samples can be prepared at a given time. It will be appreciated, however, that the instrument can be configured to prepare fewer than or greater than twenty-four samples. It will be appreciated that the system components **600** communicate with one another to enable parallel processing of the sample(s) within the instrument **500**.

The instrument interface parallel controller **608** also communicates with the instrument real time MCU **610**, the cooling system **612** and the sub-system computer **606**. The sub-system computer **606** communicates with the main computer **602**. The main computer **602** communicates with the touch screen display panel **604**.

In one embodiment, the main computer **602**, sub-system computer **606**, and/or the instrument interface parallel controller **608** are a digital processing system. The digital processing system may include a microprocessor, an ASIC (application specific integrated circuit), FPGA (field-programmable gate array), DSP (digital signal processor), or the like. In one embodiment, the display panel **604** is a 7" high definition (HD) liquid crystal display (LCD) with a touch panel. The display panel **604** is on an external surface of the instrument **500** such that the user can interact with the display panel **604**. The main computer **602** may be a stand alone system that includes the computer module **510** and display **512**. The sub-system computer **606** and instrument interface parallel controller **608** are within the enclosure **502** of the instrument **500**. As described above with reference to FIG. **5**, the user can select a protocol for processing the sample(s) with the display panel **604**. The display panel **604** communicates the user selection to the main computer **602**, sub-system computer **606** and/or parallel controller **608** to perform the protocol using the tray motor driving system **614**, heater control and detection system **616**, magnetic particle transfer system **618**, reagent release system **620**, reagent pre-mix pumping system **622** and wash butter pumping system **624**.

In one embodiment, the tray motor driving system **614** is configured to control the automatic load/eject trays **516**, **518** (from FIG. **5**) and cassette doors **520**, **522** to automatically load the cassettes (e.g., cassette **400**) for processing and eject the cassettes when processing of the sample is completed.

In one embodiment, the heater control and detection system **616** is configured to control and detect the temperature of the cassette or cassettes. The heater control and defection system may also control the heaters within the cassette to perform a close loop temperature ramping and detection. Alternatively or in addition to controlling the heaters within the cassette, the heater control and detection system **614** may include heaters that are configured as a programmable temperature controller to heat the contents of the cassette to a predefined temperature, as needed, according to the selected protocol.

In one embodiment, the magnetic particle transfer system **618** is configured to transfer magnetic particles within the cassette (e.g., cassette **400**) according to the selected protocol. In one embodiment, the magnetic particle transfer system **618** manipulates the valves **432**, **434**, **436** to transfer the magnetic particles as described above with reference to FIG. **4**.

In one embodiment, the reagent release system **620** is configured to release the reagents within the cassette. For example, the reagent release system is configured to release the PK solution, lysis solution, binding solution and magnetic beads from their respective holding chambers **416**, **418**, **420** and **422** and into the mixing chamber **414**, as described above with reference to FIG. **4**.

In one embodiment, the reagent pre-mix pumping system **622** is configured to mix the reagents in the mixing chamber **414** as described above with reference to FIG. **4**.

In one embodiment, the wash buffer pumping system **624** is configured to pump the washing solution in the cassette, as described above with reference to FIG. **4**. For example, the wash buffer pumping system **624** may be configured to actuate the pumps **446**, **448**, **450** in the wash chambers **438**, **440** and elution chamber **442**.

FIG. **6**B illustrates a block diagram of a digital system **630** in accordance with one embodiment of the invention. The illustrated digital system **630** includes a system controller module (SCM) **632**, a first instrument module (IM) 1 **634**, a second instrument modulo (IM) 2 **636** and a nth instrument module (IM) N **638**. The SCM **632** controls each of the IM 1 **634**, IM 2 **636** and up to an nth IM N **638**. It will be appreciated that the SCM **632** may control any number of IMs as represented by N. Thus, N may be any number from 0 up to 100 or even more.

FIG. **6**C is a block diagram illustrating the system controller module **632** of FIG. **6**B in further detail. The system controller module **632** includes a main processor unit **640**, a Complex Programmable Logic Device (CPLD) **642**, a Liquid Crystal Display (LCD) **644**, a Synchronous Dynamic Random Access Memory (SDRAM) **646**, a NOR flash **648**, a NAND flash **650**, a Storage Device (SD) card **652**, a Universal Asynchronous Receiver-Transmitter (UART) **654**, a CAN-BUS **656**, a Universal Serial bus (USB) **658**, an Ethernet **660** and a system bus **662** to couple each of the components **640**-**662**.

The bus **662** or other internal communication means is for communicating information, and the main processor unit **640** is coupled, to the bus **662** for processing information. SDRAM **646**, NOR flash **648**, NAND flash **650**, and SD card **652** (referred to as memory) are for storing information and instructions to be executed by the main processor unit **640**, for storing temporary variables or other intermediate information during execution of instructions by main processor unit **640**, for storing static information and instructions for main processor unit **640**, and the like.

The system may further be coupled to a display device, such as a cathode ray tube (CRT) or a liquid crystal display (LCD) **644**, coupled to bus **662** through bus **662** for displaying information to a computer user. An alphanumeric input device **675**, including alphanumeric and other keys, may also be coupled to bus **662** through bus **662** for communicating information and command selections to the main processor unit **640**. An additional user input device is cursor control device, such as a mouse, a trackball, stylus, or cursor direction keys coupled to bus **662** through bus **662** for communicating direction information and command selections to main processor unit **640**, and for controlling cursor movement on display device **644**.

Another device, which may optionally be coupled to computer system, is a communication device, such as UART **654**, CANBUS **656**, USB **658**, and Ethernet **660**, for accessing other nodes of a distributed system via a network. The communication device may include any of a number of commercially available networking peripheral devices such as those used for coupling to an Ethernet, token ring, Internet, control area network (CAN), wide area network (WAN), and wireless network (WIFI). The communication device may further be a null-modem connection via UART, or any other mechanism that provides connectivity between the computer system and the outside world, or any other mechanism that provides connectivity between the controller computer system and instrument modules. Note that any or all of the components of this system illustrated in FIG. **6**C and associated hardware may be used in various embodiments of the present invention.

It will be appreciated by those of ordinary skill in the art that any configuration of the system may be used for various purposes according to the particular implementation. The control logic or software implementing the present invention can be stored in SDRAM **646**, NOR Flash **648**, NAND flash **650**, SD card **652**, FPGA, CPLD or other storage medium locally or remotely accessible to main processor unit **640**.

It will be apparent to those of ordinary skill in the art that the system, method, and process described herein can be implemented as software stored in memory and executed by main processor unit **640**. This control logic or software may also be resident on an article of manufacture comprising a computer readable medium having computer readable program code embodied therein and being readable by the storage device and for causing the main processor unit **640** to operate in accordance with the methods and teachings herein.

The present invention may also be embodied in a handheld or portable device containing a subset of the computer hardware components described above. For example, the handheld device may be configured to contain only the bus **662**, the main processor unit **640**, and SDRAM **646**. The handheld device may also be configured to include a set of buttons or input signaling components with which a user may select from a set of available options. The handheld device may also be configured to include an output apparatus such as a liquid crystal display (LCD) or display element matrix for displaying information to a user of the handheld device. Conventional methods may be used to implement such a handheld device. The implementation of the present invention for such a device would be apparent to one of ordinary skill in the art given the disclosure of the present invention as provided herein.

The present invention may also be embodied in a special purpose appliance including a subset of the computer hardware components described above. For example, the appliance may include a main processor unit **640**, SDRAM **646** and bus **662**, and only rudimentary communications mechanisms, such as a small touch-screen that permits the user to communicate in a basic manner with the device. In general, the more special-purpose the device is, the fewer of the elements need to be presented for the device to function. In some devices, communications with the riser may be through a touch-based screen, USB devices, or similar mechanism.

It will be appreciated by those of ordinary skill in the art that any configuration of the system may be used for various purposes according to the particular implementation. The control logic or software implementing the present invention can be stored on any machine-readable medium locally or remotely accessible to processor. A machine-readable medium includes any mechanism for storing or transmitting information in a form readable by a machine (e.g. a computer). For example, a machine readable medium includes read-only memory (ROM), random access memory (RAM), magnetic disk storage media, optical storage media, flash memory devices, electrical, optical, acoustical or other forms of propagated signals (e.g. carrier waves, infrared signals, digital signals, etc.).

FIG. **6**D is a block diagram illustrating the instrument modules **634**, **636**, **638** of FIG. **6**B in further detail. The instrument modules **634**, **636**, **638** include a databus **664**, a stepper motor controller **666**, initial data **667**, a main stopper controller **668**, an ADC reader **670**, an input data device **672** and an output data device **674**. The stepper motor controller **666**, initial data **666**, main stepper controller **668**. Analog-to-Digital Converter (ADC) reader **670**, input data device **672** and output data device **674** are each coupled to the databus **664**.

In the embodiment illustrated in FIG. **6**D, the instrument module is shown for the tray motor driving module of FIG. **6**A. It will be appreciated that the instrument modules for the other modules of FIG. **6**A will have similar components as the illustrated instrument module; however, the inputs and outputs coupled with the instrument modules may vary.

The illustrated databus **664** is also coupled with a MCU **676**. The stepper motor controller **666** is also coupled with the motor sensor **678**, motor driver 2 **680** and motor driver 3 **682**. The main stepper controller **668** is also coupled with the motor driver 1 **684** and protect sensor **686**. The ADC reader **670** is also coupled with the ADC **688**. The input data device **672** is also coupled, with the door sensor **690**, main motor home sensor **692**, and cassette sensor **694**. The output data device **674** is also coupled with the fan **696** and the heater **698**.

FIG. **7** illustrates a tray driving motor assembly module **700**. In one embodiment, the tray driving motor assembly module **700** is part of the tray motor driving system **614** of FIG. **6**. In one embodiment, the tray driving motor assembly module **700** is within the instrument module **508** of the instrument **500** as described above with reference to FIG. **5**.

The tray driving motor assembly module **700** includes an alignment plate **702**, a first drive shaft retention block **704**, a second drive shaft retention block **706**, a load driving shaft **708**, a main driving motor **710**, a first parallel shaft **712**, a second parallel shaft **714**, a first parallel linear drive **716**, a second parallel linear drive **718**, a first load resistance tray **720**, a first door **722**, a second load resistance tray **724** and a second door **726**.

The main drive motor **710** is coupled with the load driving shaft **708** via the retention blocks **704**, **706** to automatically load and eject the rack trays **720**, **724** into the instrument. The trays **720**, **724** also slide along the parallel shafts **712**, **714** with the main drive motor **710** and the drives **716**, **718** to load and eject the racks **720**, **724**. The motor **710** and/or drivers **712**, **714** can also be used to open and close the doors **722**, **726**.

FIG. **8** illustrates a reagent release and pre-mix assembly module **800**. In one embodiment, the reagent release and pre-mix assembly module **800** is part of the reagent release system **620** and reagent pre-mix pumping system **622**. In one embodiment, the reagent release and pre-mix assembly module **800** is within the instrument module **508** of the instrument **500** as described above with reference to FIG. **5**.

The reagent release and pre-mix assembly module **800** includes a precision vertical engagement driving motor **802**, a vertical drive shaft **803**, a stand **804**, a first plunger assembly **806**, a second plunger assembly **808**, a first parallel horizontal pump activation motor **810**, a second parallel horizontal pump activation motor **812**, first, second, third and fourth horizontal parallel linear driving shafts and bearings **814**, **816**, **818** and **820**, and first, second, third, and fourth vertical parallel linear bearings **822**, **824**, **826** and **828**.

In one particular embodiment, each of the plunger assemblies **806**, **808** includes twelve plungers (e.g., one plunger for each cassette in the magazine). It will be appreciated that the plunger assemblies **806**, **808** may have fewer than or greater than twelve plungers.

FIG. **9** is a side view of reagent release and pre-mix assembly module **800** of FIG. **8**. As shown in FIG. **9**, the reagent release and pre-mix assembly module **800** of FIG. **8** also includes a vertical position sensor **830**.

With reference to FIGS. **8** and **9**, the stand **804** is coupled with the vertical drive shaft **803**, which is coupled with the vertical engagement driving motor **802** to vertically position the stand **804**. The plunger assemblies **806**, **808** are coupled with the stand **804** and are, thus, also vertically positioned with the stand **804** when the motor **802** is actuated. The vertical position sensor **830** is coupled with the stand **804** to sense the position of the stand **804** and/or plunger assemblies **806**, **808**. The vertical position sensor **830** communicates with a controller to control actuation of the motor **802**. The plunger assemblies **806**, **808** are also actuatable horizontally via the horizontal drive shafts and bearings **814-820**, which are coupled with the horizontal motors **810**, **812**.

The plunger assemblies **806**, **808** are actuated in a vertical direction to align the plungers **806**, **808** with one of the holding chambers of the cassette **400**. The plunger assemblies **800**, **808** are also actuated horizontally to force the contents of the holding chambers into the mixing chamber of the cassette **400**. The plunger assemblies **806**, **808** are then repositioned vertically to align with another holding chamber and are similarly actuated horizontally to force the contents of the holding chamber into the mixing chamber according to the selected protocol. In one embodiment, the plunger assemblies **806**, **808** are also actuated to actuate the pump **444** that mixes the contents of the mixing chamber of the cassette **400**.

FIGS. **10** and **11** illustrate a heater and temperature sensor assembly module **1000**. In one embodiment, the heater and temperature sensor assembly module **1000** is part of the heater control and detection system **616**. In one embodiment, the heater and temperature sensor assembly module **1000** is within the instrument module **508** of the instrument **500** as described above with reference to FIG. **5**.

The heater and temperature sensor assembly module **1000** includes a precision vertical engagement driving motor **1002**, a vertical position sensor **1004**, a rack **1006**, a first vertical linear bearing **1008**, a second vertical linear bearing **1010**, a plurality of heater and thermal sensor connectors **1012** and a plurality of individually controlled parallel heaters and thermal sensors **1014**. In one embodiment, the plurality of individually controlled parallel heaters and thermal sensors **1014** are self-aligned with the plurality of heater and thermal sensor connectors **1012**.

In one particular embodiment, the heater and temperature sensor assembly module **1000** includes twenty-four heater and thermal sensor connectors **1012** and twenty-four individually controlled parallel heaters and thermal sensors **1014**. It will be appreciated that the heater and temperature sensor assembly module **1000** may include fewer than or greater than twenty-four connectors **1012** and/or heaters/sensors **1014**.

The vertical linear bearings **1008**, **1010** are coupled with the vertical engagement driving motor **1002** to vertically position the rack **1006**. The plurality of heater and thermal sensor connectors **1012** and plurality of individually controlled parallel heaters and thermal sensors **1014** are coupled with respective sides of the rack **1006**. The plurality of heater and thermal sensor connectors **1012** and plurality of individually controlled parallel heaters and thermal sensors **1014** are vertically positionable by vertically positioning the rack **1006**. The vertical precision position sensor **1004**, coupled with the rack **1006**, can be used to accurately position the plurality of heater and thermal sensor connectors **1012** and plurality of individually controlled parallel heaters and thermal sensors **1014**.

FIGS. **12** and **13** illustrate a wash buffer pumping assembly module **1200**. In one embodiment, the wash buffer pumping assembly module **1200** is part of the wash buffer pumping system **624**. In one embodiment, the wash buffer pumping assembly module **1200** is within the instrument module **508** of the instrument **500** as described above with reference to FIG. **5**.

The wash buffer pumping assembly module **1200** includes a rack **1202**, a plurality of parallel vertical pump engagement plungers **1204**, a first parallel vertical pump activation motor **1206**, a second parallel vertical pump activation motor **1208**, and first, second, third and fourth vertical parallel linear driving shafts and bearings **1210**, **1212**, **1214** and **1216**. As shown in FIG. **13**, the wash buffer pumping assembly module **1200** also includes first and second vertical precision position sensors **1218** and **1220**.

The first vertical pump activation motor **1206** is coupled with the first and second vertical parallel linear driving shafts and bearings **1210**, **1212** to vertically position a first set of parallel vertical pump engagement plungers **1204***a*. Similarly, the second vertical pump activation motor **1206** is coupled with the third and fourth vertical parallel linear driving shafts and bearings **1214**, **1216** to vertically position a second set of parallel vertical pump engagement plungers **1204***b*.

The plungers from the vertical pump engagement plungers **1204** engage with the cassette (e.g., cassette **400**) to actuate the pumps **446**, **448**, **450** in the wash chambers **438**, **440** and elution chamber **442** according to the selected protocol.

FIGS. **14** and **15** illustrate a magnetic particles transfer assembly module **1400**. In one embodiment, the magnetic particles transfer assembly module **1400** is part of the magnetic particle transfer system **618**. In one embodiment, the magnetic particles transfer assembly module **1400** is within the instrument module **508** of the instrument **500** as described above with reference to FIG. **5**.

The magnetic particles transfer assembly module **1400** includes a rack **1402**, a precision vertical engagement driving motor **1402**, a first particle transfer linear motor **1404**, a second particle transfer linear motor **1406**, first, second, third, and fourth gear rack retention roller bearings **1408**, **1410**, **1412** and **1416**, first and second vertical linear bearings **1418** and **1420**, first and second driving gear racks **1422**, **1423**, a plurality of parallel precision gears **1424** and a plurality of parallel magnets and valve key shafts **1426**. As shown in FIG. **15**, the magnetic particles transfer assembly module **1400** also includes first and second linear driving shafts **1428** and **1430**, first, second, third and fourth shaft and gear rack link blocks **1432**, **1434**, **1436** and **1438**, first, second, third and fourth horizontal precision position sensors **1440**, **1442**, **1444** and **1446**, and a vertical precision position sensor **1448**.

In one particular embodiment, the magnetic particles transfer assembly module **1400** includes twenty-four parallel precision gears **1424** and twenty-four parallel magnets and valve key shafts **1426**. It will be appreciated that the magnetic particles transfer assembly module **1400** may have fewer than or greater than twenty-four gears **1424** and magnets and key shafts **1426**.

The precision vertical engagement driving motor **1402** is coupled with vertical bearings **1418**, **1420** and the rack **1403** to vertically position the rack **1403**. The plurality of parallel magnets and valve key shafts **1426** are positioned on the rack **1403** and are vertically portioned when the rack **1403** is vertically positioned. The vertical precision position sensor **1448** is coupled with the rack **1403** and motor **1402** to accurately position the plurality of parallel magnets and valve key shafts **1426** in the cassette (e.g., cassette **400**).

The particle transfer linear motors **1404**, **1405** are positioned on either end of the rack **1403** and are coupled with the linear driving shafts **1428**, **1430**, shaft and gear rack link blocks **1432-1438**, driving gear racks **1422**, gears **1424**, to horizontally position and rotate the plurality of parallel magnets and valve key shafts **1426** via the gears **1424** to transfer magnetic particles as described above with reference to FIG. **4**. It will be appreciated that the gears **1424** and magnets and shafts **1426** can be repositioned to transfer the particles with each valve of the cassette.

The foregoing description with attached drawings is only illustrative of possible embodiments of the described method and should only be construed as such. Other persons of ordinary skill in the art will realize that many other specific embodiments are possible that fall within the scope and spirit of the present idea. The scope of the invention is indicated by the following claims rather than by the foregoing description. Any and all modifications which come within the meaning and range of equivalency of the following claims are to be considered within their scope.

The invention claimed is:

1. An apparatus comprising:

a rack;

a linear drive shaft;

a plurality of gears;

first and second vertical linear bearings;

a plurality of valve key shafts disposed on a first side of the rack, each of said valve key shafts comprising a magnet at an end of said valve key shafts distal to the rack;

a linear motor coupled to the plurality of valve key shafts via the linear drive shaft and the plurality of gears, wherein the linear motor is positioned on either end of the rack;

a vertical engagement driving motor coupled to the rack, wherein:

the vertical engagement driving motor is configured to vertically position the rack, wherein said vertical engagement driving motor is coupled to the first and second vertical linear bearings; and

the linear motor is configured to horizontally position and rotate the plurality of magnets and the valve key shafts via the plurality of gears.

2. The apparatus of claim **1** further comprising a vertical position sensor coupled to the rack and the vertical engagement driving motor, wherein the vertical position sensor is configured to detect a position of the plurality of valve key shafts.

3. The apparatus of claim **1** further comprising a horizontal position sensor.

4. The apparatus of claim **1** further comprising:

a second linear drive shaft;

a second plurality of gears;

a plurality of second valve key shafts disposed on the first side of the rack, each of said second valve key shafts comprising a magnet at an end of each of said second valve key shafts distal to the rack;

a second linear motor coupled to the plurality of second valve key shafts via the second linear drive shaft and the second plurality of gears.

5. The apparatus of claim **4** wherein the linear motor is positioned at a first end of the rack and the second linear motor is positioned at a second end of the rack.

6. The apparatus of claim **4** further comprising a first driving gear rack coupled to the linear motor and comprising a second driving gear rack coupled to the second linear motor.

7. The apparatus of claim **6** wherein the first driving gear rack engages each valve shaft of the plurality of valve key shafts and wherein the second driving gear rack engages each valve shaft of the plurality of second valve key shafts.

8. The apparatus of claim **1** wherein the vertical engagement driving motor is positioned between the first end of the rack and the second end of the rack, and wherein the vertical engagement driving motor is positioned proximal to a second side of the rack that is opposed to the first side of the rack.

9. The apparatus of claim **1** wherein the plurality of gears comprises parallel gears.

10. The apparatus of claim **1** wherein the apparatus is contained within an instrument configured for parallel processing of one or more samples.

11. The apparatus of claim **10** wherein the instrument is configured to perform a protocol selected to prepare a sample of the one or more samples.

12. The apparatus of claim **11** wherein the instrument comprises a touch screen display configured to allow a user to select the protocol.

13. The apparatus of claim **10** wherein the instrument comprises a magazine having one or more cassettes.

14. The apparatus of claim **13** wherein each cassette of the one or more cassettes comprises a plurality of valves.

15. The apparatus of claim **14** wherein each valve of said plurality of valves is configured to receive the magnet at the end of one of the plurality of valve key shafts.

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